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## STUDIES ON THE GENUS CITTOTAENIA

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By RUFUS ASHLEY LYMAN

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WITH TWO PLATES

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The parasites studied were collected from rabbits in Nebraska and Kansas. A careful record was kept to give some idea of the degree of infection, and, although the number of rabbits examined is not large enough for entirely satisfactory results, yet some interesting data have been obtained. For this purpose 87 rabbits were examined; 47 were found to harbor parasites, 33 containing cestodes, 31 cysticerci, and 3 nematodes. The rabbits were of two different species, the common cotton-tail, *Lepus sylvaticus*, and the common jack, *L. melanotis*. Of the 60 rabbits killed in eastern Nebraska, 55 were cotton-tails and 5 jacks. Of the 55 cotton-tails, 38 were infected, but none of the jacks were. On the other hand, of the 27 killed in southwestern Nebraska and adjacent parts of Kansas, 12 were jacks and 15 cotton-tails. Of these 3 cotton-tails were infected, while the number of jacks infected was 7.

The cestodes taken from these rabbits represent four forms: *Cittotaenia variabilis*, *C. variabilis angusta* from *L. sylvaticus*, and *C. pectinata* and a single-pored form from *L. melanotis*.

Several specimens of the single-pored form were obtained, but were so poorly preserved that final determination of the species must be left until more material is obtained. The cestode, however, occupies a unique position, as the following facts show.

Each proglottis always contains only one set of female glands. The genital pores are unilateral and always on the right margin of the strobila. In this it resembles the genus *Anoplocephala*, but differs from it as regards the position of the female glands and the distribution of the testes. In *Anoplocephala* the testes are located in the aporose, the ovary in the pore side of the proglottis (Stiles '96); but in the present form the testes are distributed throughout the

proglottis, and the ovary is located in the median line. This resembles somewhat the conditions found in *Bertia americana* Stiles 1896, but the testes extend the whole length of the proglottis as well as to the excretory canals on either side (fig. 9), and the female glands are always located in the median line in succeeding segments, and not right and left of the median line, as in *B. americana* and *B. americana leporis*.

So far as has been ascertained, the degree of infection by cestodes remains about the same throughout the year, at least for the species *Cittotaenia variabilis*. This form has been collected at all seasons and seems to be about as frequent in the winter months as in the summer. Riehm (81) states that it is said that *C. pectinata* occurs in the European hares only in the fall and the first half of the winter, but the adult parasite was found in Rawlins county, Kansas, as early as March and throughout all the spring and summer months.

The number of worms found in a single rabbit seems to vary with different species. The largest number of *C. variabilis* found in a single rabbit was 5. They often occur singly, but generally in pairs. Twelve individuals of *C. variabilis angusta* were found in one rabbit. *C. pectinata* seems to occur in greater numbers. Goeze mentioned the fact that 20 or 30 are found in a single host. In the present case as many as 54 were taken from one rabbit.

#### THE GENUS CITTOTAENIA

This genus was first proposed by Riehm in 1881. In it and in *Dipylidium* R. Leuckart he placed the double-pored forms of rabbit cestodes, while the single-pored forms he placed in *Taenia*. However, in the same year, he rejected *Cittotaenia* as a genus and placed the only species in *Dipylidium*. In 1891 R. Blanchard proposed a new genus, *Moniezia*, based upon the number of genital pores. In this genus he included the double-pored forms of cattle, sheep, and allied animals and also *T. festiva* R. 1819 from *Macropus giganteus*, *T. marmotae* Frölich 1802 from *Arctomys marmota*, and *T. pectinata* Goeze 1782, *D. Leuckarti* Riehm 1881, and *D. latissimum* Riehm 1881 from rabbits. Blanchard placed the single-pored forms in *Anoplocephala*. In 1893 Railliet proposed the new genus *Ctenotaenia*, with *T. marmotae* as type, and placed here *Ct. Goezei* (=Riehm's *C. latissima*), *Ct. Leuckarti*, and *Ct. pectinata*. The establishment of this genus was an error on the part of Railliet, who

evidently overlooked Riehm's first paper. The same mistake was made by Stiles in 1895, and by Stiles and Hassall in 1896, who accepted Railliet's genus *Ctenotaenia*. Because of the many differences between the double-pored cestodes of rodents and ruminants, Stiles in 1893 separated the double-pored forms of rodents, which had been placed in *Moniezia* by Blanchard, from that genus, but did not attempt to classify them. In 1896 he adopted Riehm's formerly discarded genus, *Cittotaenia*, for the double-pored forms, giving it priority, of course, to Railliet's genus *Ctenotaenia*. Stiles distributed the single-pored forms among the genera *Anoplocephala* E. Blanchard 1848, *Andrya* Railliet 1893, and *Bertia* R. Blanchard 1891.

*Cittotaenia pectinata* (Goeze 1872 partim, Riehm 1881) Stiles and Hassall 1896.

The history of this parasite is thoroughly reviewed by Stiles (1896). The species has been reported from Germany and France, but up to the present instance it has not been reported in America, and Stiles (1896) considers his *C. variabilis* the American representative of *C. pectinata*.

The parasites assigned to this species were collected in Buffalo county, Nebraska, and Rawlins county, Kansas, from *Lepus melanotis*, and are certainly not identical with *C. variabilis* Stiles and Hassall (96), but resemble very closely the form described by Riehm as *Dipylidium pectinatum*, and by Stiles and Hassall (96) as *C. pectinata*, differing only in some minor particulars, to which attention will be called in the description of the various organs.

External Characteristics.—The adult strobilae do not vary greatly in size. In 54 specimens of various ages taken from a single rabbit the parasites range from 7 mm. to 71 mm. in length. The smallest is 7 mm. long and possesses 40 proglottides. The strobila is leaf-like in form, a characteristic which presents itself in all of the young forms and persists more or less perfectly as long as all the proglottides remain intact. The general shape gives one the impression of a large liver fluke, being widest near the center of the body and gradually tapering toward both ends. In the larger specimens the anterior portion is comparatively narrow, becoming lanceolate. The posterior proglottides always become narrower and longer, often reaching 1.5–2 mm. in length. The strobila attains its greatest width,

9–10 mm., about 15–20 mm. back of the head, and then remains comparatively uniform in breadth until near the posterior end. Following is a table showing the length, the breadth in different regions, and the number of proglottides present in five typical strobilae. All measurements are given in millimeters.

TOTAL LENGTH OF STROBILA	WIDTH 2 MM. BACK OF SCOLEX	WIDTH 10 MM. BACK OF SCOLEX	WIDTH IN WIDEST PLACE	WIDTH OF POSTERIOR ATTACHED PROGLOTTIS	NO. OF PROGLOTTIDES	
44	3	6	8.5	2.5	140	Every proglottis present.
52	3.5	6	9.5	2	130	Every proglottis present.
68	3.5	5.5	7	4	125	Posterior proglottis gone.
27	3.5	7	8	4	110	Posterior proglottis gone.
71	4.5	7	9	8	140	Several gone.

The proglottides are always broader than long. When the terminal proglottis is present, it has the form of a bulb applied closely to the preceding proglottis. At its extreme posterior part is a noticeable depression, the opening of the excretory canals. The posterior border of each proglottis is smooth and overlaps the following proglottis but slightly. The genital pores, two in each proglottis, are situated about the middle of the segment margin. They are never prominent, and usually can be distinguished only by the aid of a lens, and often only in section. The cirrus has never been found protruding from the pore.

The head is dome-shaped (fig. 6) and its measurements are much larger than those given by either Stiles or Blanchard for *C. pectinata*. Stiles in his diagnosis gives 0.25 mm. for the diameter and 0.125 mm. for the thickness of the head, and says that the suckers are small, but gives no measurements. Blanchard (1891) gives measurements as follows: head, 315  $\mu$  to 340  $\mu$  broad; suckers 142  $\mu$  long by 135  $\mu$  broad; opening 80  $\mu$  long by 53  $\mu$  broad. In the present form the diameter of the head varies from 0.41 to 0.45 mm.; the thickness from 0.28 to 0.31 mm. While the head is much larger, the suckers are small, being about 0.12 mm. long by 0.088 mm. broad. The cavity of the sucker measures from 64 to 74  $\mu$  long by 28 to 34  $\mu$  broad. In section the suckers are seen to open nearly

straight forward or at a very small angle outward. In all cases, from the smallest to the largest strobila, the neck is absent, segmentation beginning immediately at the base of the head.

MUSCULATURE.—There are two dorsal and two ventral plates of longitudinal fibers (fig. 4, *l m*). The outer plates are much the larger. The fibers tend to run in bundles, and single fibers often run through 10 to 40 proglottides. Certain fibers running in adjacent bundles branch off and form anastomoses with other bundles, and so a dense network of fibers is formed. The inner longitudinal muscle plate is not as highly developed as the outer. Near the lateral margins of the strobila, the plates of the dorsal and ventral sides approach each other and finally meet. The inner plate always remains separate from the outer, but its fibers become much less distinct at the margin of the proglottis. Directly within the inner longitudinal plates there are two transverse plates of fibers which run entirely across the proglottis and enclose the male and female reproductive glands (fig. 4, *t m*). A third system is present as sagittal fibers (fig. 4, *s m*). They run dorso-ventrally, forming a dense network in the parenchyma between the dorsal and ventral transverse plates. They branch greatly, and these branches form a network around the testicles and the various female glands. Many of them pierce the transverse and the longitudinal plates.

EXCRETORY SYSTEM.—There are four longitudinal canals, two dorsal and two ventral. These persist throughout the anterior, the middle, and most of the posterior portion of the strobila. In the extreme posterior portion they become so branched that it is often impossible to distinguish dorsal canals from ventral. This is quite different from the description given by Stiles, who, in his diagnosis (96), says that the dorsal canal was not observed. Riehm (81) remarks that the dorsal canal becomes obliterated some distance from the head. In the present form the dorsal and the ventral canals are nearly the same in size. The diameter of the ventral canal varies somewhat, while the dorsal remains more nearly constant. The diameter of the ventral canal varies from  $34\ \mu$  to  $48\ \mu$  the dorsal from  $34\ \mu$  to  $40\ \mu$ . The dorsal canal (fig. 4, *d c*) lies dorsal and slightly median of the ventral, about 0.75 mm. from the margin of the proglottis. In the head the dorsal canals unite, likewise the ventral. The dorsal canals pass dorsal to the nerve ganglion, while the ventral canals run ventral to them, and the two

canals formed by the union of the four unite between the suckers, forming a single canal, which ends as a blind tube near the anterior point of the head (fig. 2, *b e c*). A loop is formed here by the canals around the ganglia, and the blind sac is an anterior projection from the point where the ducts unite. The ventral canals are connected by a transverse canal in the posterior portion of each proglottis. The transverse canals of adjacent proglottides are again connected by secondary longitudinal canals, which often branch and give the parenchyma the appearance of being divided into little islands (fig. 7). This network of secondary longitudinal canals is more prominent in the anterior than in the posterior portion of the strobila. When the posterior proglottis is attached, the excretory canals come together, forming a more or less irregular reservoir (fig. 3, *r*), which opens at the excretory pore through many canals.

NERVOUS SYSTEM.—Two ganglia are located in the head just back of the suckers. They lie between the arms of the loop formed by the dorsal and the ventral canals (fig. 2). Each ganglion is about  $53\ \mu$  long by  $40\ \mu$  wide. They are connected by transverse commissures. Small nerves are given off anteriorly to the suckers. The main nerve trunks leave the ganglia at the sides, run toward the margins of the head, and turn backward. There are three distinct longitudinal nerves present. Two run ventral to the genital ducts and one dorsal. The main trunk lies just outside of the ventral longitudinal canal (fig. 4, *m n*). It runs in about the middle of the strobila in the dorso-ventral direction except, where it passes beneath the genital canals, it dips slightly ventrally (fig. 5, *m n*). Its average diameter in the anterior region of the strobila is  $60\ \mu$ . In the posterior portion of each proglottis there is a ganglionic enlargement from which nerve fibers are given off. Some run in the direction of the genital pore, while others pass toward the median portion of the proglottis, but their course can not be traced. No transverse proglottidal commissures have been found. The dorsal and the ventral trunks are about the same size, averaging  $13\ \mu$  in thickness. The ventral lies directly below the main trunk, and the dorsal directly above, but dorsal to the genital ducts. Both secondary trunks are connected with the primary by commissures in the posterior portion of each proglottis (fig. 5, *c o*). From this section the relative position of nerve trunks, commissures, and

genital ducts can be seen. The posterior commissures are constant. Just behind the vagina and cirrus pouch are the other commissures connecting the main trunk with the secondary trunks, but these are not as well developed as the posterior commissures and are not as constant.

MALE REPRODUCTIVE ORGANS.—The anlagen of all the genital ducts appear in the proglottides immediately behind the head. The anlagen of the testes appear first about 6 mm. or 7 mm. from the anterior extremity of the head. They develop rapidly and do not atrophy in the posterior region of the strobila, the capsules nearly always remaining in perfect form. Even in the posterior proglottis they are found grouped around the excretory pore and between the canals leading to the pore (fig. 3, *t*). There are from 100 to 125 in each proglottis, arranged in a quadrangle confined to the dorsal portion of the proglottis and posterior to the uterus. They extend posterior from the ovaries to the longitudinal canals (fig. 1). This is a characteristic of much importance, since Stiles quotes it as one of the important differences between the European form, *C. pectinata*, and the American representative of the same species, *C. variabilis*, in which the testes extend to, but not beyond, the ovaries. They are nearly spherical in form, averaging  $70\ \mu$  in diameter, but often attaining a thickness of  $92\ \mu$ . Running from each testis is a small duct, which joins the transverse tubule. There are two of these tubules on each side of the proglottis. One receives the ducts from the testes lying in the middle portion of the proglottis, while the other receives those from the testes lying back of the ovary and those lying externally toward the longitudinal canals. These tubules join posterior to the ovary and form the vas deferens.

The vas deferens runs dorsal to the ovary in an outward oblique direction toward the anterior end of the proglottis. Its usual length is 0.75 mm. to 1 mm. In the younger stages it is not twisted, but later it becomes greatly convoluted (fig. 4, *v d*), forming loops in the dorso-ventral direction only.

The vesicula seminalis is quite variable. Often there are one or more small swellings in the vas deferens just before reaching the cirrus pouch, but, when present, they are very much smaller than the figures of Riehm would indicate. There is usually just inside the cirrus pouch an enlargement which, in some cases, nearly fills the pouch and is filled with a dense mass of sperm.



The nozzle-shaped cirrus pouch is very large, extending some distance mediad from the longitudinal canals (fig. 1, *c p*). Its length varies from 0.925 to 1.075 mm. and its width from 65  $\mu$  to 85  $\mu$ . The pouch is muscular, consisting of two sets of muscle fibers (fig. 8). The outer layer consists of longitudinal fibers; the inner, which is also the thicker, consists of circular fibers. The cirrus wall averages from 5  $\mu$  to 24  $\mu$  in thickness. It contains both circular and longitudinal fibers arranged similarly to those of the cirrus pouch. Although the cirrus pouch lies dorsal to the vagina, it does not open dorsally to the latter, but the vagina so twists around that its opening is posterior to that of the cirrus and in the same frontal plane (fig. 1). The sheath of the cirrus is composed of spongy tissue (fig. 8, *s t*). Riehm (81) in one of his figures indicates both the cirrus and the vagina as opening externally into a comparatively shallow cloaca. In the present form the cloaca is a narrow duct opening upon the top of a small cone which is situated at the bottom of the genital pit (fig. 1). The genital pit or pore is situated near the middle of the margin and is very indistinct. There are no projecting lips and, in many cases, no depression is present. The largest pits measure 56  $\mu$  in diameter and 32  $\mu$  deep.

FEMALE REPRODUCTIVE ORGANS.—These organs appear earlier than those of the male. The anlagen of the glands are found in the proglottides immediately behind the head, but the uterus does not appear until somewhat later. Back of the middle of the strobila all of the female organs, except the uterus, begin to atrophy, and in the posterior proglottides only remnants of the vagina remain. The ovary, shell gland, and vitellarium lie about 1.6 mm. from the margin of the proglottis, nearer the ventral side, and nearly fill the proglottis in antero-posterior diameter. Each proglottis contains two sets of female glands.

The vagina lies ventral to the cirrus pouch, the distal end becoming posterior and opening behind the cirrus. At its distal end, the lumen is very small and the cuticular lining very thick. As it runs mediad the lumen widens and the walls become thinner until it reaches a point just within the longitudinal excretory canals, when its walls become very thin, and it expands into the external receptaculum seminis, the first receptaculum seminis of Riehm (fig. 1, *e r s*). This thick-walled portion of the vagina is surrounded by a

thin layer of circular muscle fibers, and outside of the fibers is a single layer of cells which stain deeply. These cells, near the termination of the vagina, have the appearance of pavement epithelium, but farther mediad they become columnar (figs. 1 and 8, *d s c*). The cuticular lining of this portion of the vagina is covered by cilia (fig. 8 *c i*). The combined length of the first portion of the vagina and the external receptaculum is about 1 mm., or equal to the length of the cirrus pouch, and they both vary in the same ratio. The widest portion of the external receptaculum is 40  $\mu$ . After reaching the external receptaculum the character of the vagina changes greatly. The deeply staining cells entirely disappear, the walls become very thin, and no muscle fibers are present. After leaving the external receptaculum the vagina is smaller in diameter as it runs mediad until it reaches the internal receptaculum, the second of Riehm (fig. 1, *i r s*). The narrow portion is about 0.625 mm. long. The internal receptaculum does not differ from the external in structure, but is larger, averaging 208  $\mu$  long and 80  $\mu$  in diameter. The internal and the external receptacula and the portion of the vagina between them is always full of sperm.

The shell gland surrounds the oviduct just at the entrance of the vitelline duct. In cross-section it is seen to consist of spindle-shaped cells surrounding the oviduct. Its diameter varies from 90 to 100  $\mu$ .

The vitellarium lies posterior and dorsal to all other female glands (fig. 1, *v t*). It is more or less bean-shaped and divided into lobes or pouches by infoldings of its walls. Its length is about 200  $\mu$ , its width, 90  $\mu$ . The vitelline duct is about 25  $\mu$  long and leaves the gland from its concave side. The contents of the gland are finely granular and stain deeply.

The ovary consists of numerous pouches which extend antieriad laterad, and ventrad, but is located dorsally and posteriorly by the sides of the vitellarium. In these individuals the ovary is not bilobed as stated by Riehm, and the shape of the pouches is different from that indicated by his figures. They are Indian-club shaped, averaging about 112  $\mu$  long and being widest, 16  $\mu$ , at their distal ends. Each pouch is connected with the common reservoir (fig. 1, *r o*) by a narrow neck only large enough for one ovum to pass. The common reservoir is an oval structure about 57  $\mu$  wide by 95  $\mu$  long, into which all the pouches empty, and from which the oviduct

leads. The whole ovary, together with these pouches, is about 0.475 mm. long by 0.15 mm. wide.

The oviduct (fig. 1, *o v*) is very simple. It runs posteriad from the reservoir of the ovary toward the yolk-gland. Its course is slightly convoluted. Beyond the opening of the vagina and the vitelline duct into the oviduct, the latter passes through the shell gland, at the same time turning forward, becomes the ootype, and enters the uterus just below the ovary. Its diameter is about 10  $\mu$ .

There is never more than one uterus in a single proglottis. In the early stages, it is a simple, transverse, rod-like organ which runs dorsal to all other organs and extends laterally beyond the excretory canals. In older proglottides the walls of the uterus become slightly digitate by the growth of shallow proximal and distal pouches, which are always simple. The ripe proglottis is almost completely filled by the uterus.

The ova are more or less irregular or polyhedral in form, probably due to pressure or shrinkage, since in the younger proglottides they are spherical. They measure 50 to 58  $\mu$  in diameter, and the bulb of the pyriform body is 16 to 21  $\mu$  thick. The horns are long and usually filamentous.

*Cittotaenia variabilis* (Stiles 1895) Stiles and Hassall 1896.

Some additional points have been worked out in the structure of this species.

This form shows variations in almost every possible direction. The strobila many attain a length of 17 or 18 cm. The head, though quite constant in form, varies greatly in size. It is spherical in general form, but slightly flattened on top and at the sides. In the present forms it varies from 0.462 to 0.872 mm. in diameter. The suckers are not only variable in size but also in shape. They are more commonly spherical, about 0.2 mm. in diameter, with a cavity 0.094 mm. across. Sometimes they are slightly elliptical, measuring 0.282 mm. long by 0.106 mm. broad, but this elliptical form may be due to contraction.

MUSCULATURE.—The muscular system is even more highly developed than in *C. pectinata*. The muscle fibers are larger, run in larger bundles, and lie closer together. A subcuticular layer of fibers, consisting of fibers running in both the longitudinal and the transverse directions, is especially well developed.

EXCRETORY SYSTEM.—This system is simple, consisting of four longitudinal trunks which persist throughout the strobila. The ventral canal is thin-walled and much the larger. In cross-section it is seldom circular, but is usually longer in the dorso-ventral direction (fig. 10 *v c*). Its dorso-ventral diameter averages about 0.217 mm.; the transverse, 0.095 mm. The dorsal canal is smaller, and, in a true transverse section, circular, or nearly so, in outline. It lies dorso-median of the ventral canal, and its average diameter is 60  $\mu$ . The character of its walls is very different from the ventral canal, since it has a thick cuticular lining around which is a thick layer of muscle fibers (fig. 10, *d c*). All canals unite in the head between the suckers, forming a loop. There is, however, no anterior projecting canal from their junction, as in *C. pectinata*. The ventral canals are connected in the posterior portion of each proglottis by a transverse canal, but no secondary longitudinal canals connecting the transverse canals are found.

NERVOUS SYSTEM.—The material used for the study of the nervous system in this species was preserved in vom Rath's killing solution and some additional points were obtained, but such structures as the proglottidal nerve rings, which Tower (97) describes for *Moniezia expansa* and *M. planissima*, could not be traced. The ganglia occupy the same position behind the suckers as in *C. pectinata*, but the commissures connecting them can be seen more distinctly. Anteriorly there are given off nerves which run around the suckers and toward the anterior point of the head. A cross-section of the head (fig. 11) shows the position of the ganglia with reference to the dorsal and the ventral longitudinal canals. They lie between the canals which pass forward to unite between the suckers. In this species, also, three longitudinal nerve trunks are present, two running ventral and one dorsal to the genital ducts. But, instead of the three lying in the same sagittal plane as in *C. pectinata*, the two secondary trunks lie outside of the main trunk toward the margin of the proglottis (fig. 10, *mn, dn, vn*). No commissures could be found connecting the main and the secondary trunks as in *C. pectinata*, but the inability to trace them may be due to the thickness of the sections and the density of the stain. A ganglion is found on the main trunk in the posterior part of each proglottis, from which nerve fibers run toward the genital pore and are lost in the tissue around the pore. Others are given off from

the inner side, but their terminations can not be found. Smaller branches are given off throughout the course of the nerve (fig. 12).

MALE REPRODUCTIVE ORGANS.—The testes number from 75 to 100 in each proglottis and are confined to the posterior side of the uterus and to the dorsal portion of the strobila. They extend to, but never beyond, the ovary; they are oval in form, measuring about  $80\ \mu$  by  $100\ \mu$ . Each one is surrounded by a thick layer of muscle fibers, the probable function of which is to force the sperm out of the testis into the duct, as in *C. pectinata*.

The vas deferens is convoluted in the dorso-ventral direction only (fig. 10, *vd*), but it has no peculiar characteristic. There are no enlargements found in its course, the small vesicula seminalis being situated just inside the cirrus pouch. It is rarely more than 12 to  $20\ \mu$  in diameter.

The cirrus pouch (fig. 13) may reach a length of 0.4 mm., but it is usually much less. Its diameter is more nearly uniform throughout its length than in *C. pectinata*, often being  $50\ \mu$ . Its muscular walls are highly developed, there being an outer longitudinal layer of fibers and an inner circular, the combined thickness of both often reaching  $16\ \mu$ .

The cirrus is from  $5\ \mu$  to  $8\ \mu$  in diameter. It opens dorsally to the vagina (fig. 10). In this species the cloaca is surrounded by a sphincter muscle, the wall band of which is  $13\ \mu$  thick (fig. 13, *sp m*). Its probable function is to contract in self-fertilization and to force the male products to pass up the vagina.

The genital pore is situated in the middle of the lateral margin. Although it is not prominent, it is easily detected, since the margin of the proglottis is depressed near the pore. Usually there is a little pit (fig. 13, *g p*), or pocket, opening by a narrow neck, but the lips may be so closely applied to the inner surface of the pocket that the cavity is obliterated. The pit measures  $13\ \mu$  deep by  $21\ \mu$  wide.

FEMALE REPRODUCTIVE ORGANS.—The vagina opens into the cloaca ventral to the cirrus (fig. 10, *v*), and lies ventral to the cirrus pouch throughout its length. It is about  $10\ \mu$  thick, and there is no enlargement corresponding to the external receptaculum of *C. pectinata*, the organ remaining narrow and of about the same caliber until it swells into the receptaculum near the ovary. The first 0.7 or 0.8 mm. of the vagina is surrounded by deeply staining cells as

in *C. pectinata*. The receptaculum seminis varies in length; its average is about 65  $\mu$ .

The ovary, shell gland, and vitellarium are situated about 1.3 mm. from the lateral margin and resemble the corresponding organs in *C. pectinata*, but are usually longer in transverse diameter and narrower in an antero-posterior direction. The yolk gland is elliptical in form, 0.266 mm. long (*i. e.*, across the proglottis) and 0.088 mm. wide. The ovary is 0.69 mm. long, in the same direction, and 0.1 mm. wide. The ovarian tubules are much heavier than in *C. pectinata*, being from 37 to 45  $\mu$  wide and from 75 to 100  $\mu$  long, and are connected with the common reservoir by thick necks (fig. 10, *o*). The shell gland occupies a position corresponding to that in *C. pectinata*, and all the female glands are crowded closely together.

The uterus may be single or double in the same strobila. In some cases, all, or nearly all, are single; in others, all, or nearly all, are double. The uterus appears as a single transverse tube which lies dorsal and extends beyond the excretory canals. In the older stages it becomes slightly and irregularly digitate, and finally entirely fills the proglottis. If two uteri are present, their blind ends become closely applied in the median line and can be distinguished only in section.

The ova average about 58  $\mu$  in diameter and the bulb of the pyriform body, 16  $\mu$ . The horns are usually about 1.5 times as long as the pyriform body is thick, and are usually straight, do not cross, and are not filamentous.

*Cittotaenia variabilis angusta*.

This variety is only about 2 mm. broad, but often reaches a width of 3 mm. The internal anatomy differs from that of *C. variabilis* principally in size, all the organs being proportionally smaller. There are a few peculiarities, however, both in the shape and position of certain organs which seem to be quite constant.

1. All the organs are situated in the posterior portion of the proglottis, leaving the anterior portion completely bare (fig. 22).
2. The genital pores are situated close to the posterior margin of the proglottis (fig. 22, *g p*).
3. The ovaries, in proportion to the width of the strobila, are situated far from the lateral margins, the distance from the lateral

margin to the ovary being almost as great as the distance between the ovaries. Consequently the testes are more closely crowded together (fig. 22).

4. The ovary has a very characteristic appearance. The diameter of each pouch is nearly the same throughout its length.

5. The number of uteri in each proglottis within the same strobila is more variable than in the type of the species.

PROGLOTTIDAL VARIATIONS.—A study of the variations in the proglottides shows some interesting facts in the various forms. In all the specimens of *C. pectinata*, the external appearance of the proglottides is perfectly normal. No irregularly developed or abnormal proglottides appeared, and no cases of intercalation, such as Blanchard's (1891) figures show, are found. Concerning the number of sets of reproductive glands, a very peculiar fact presents itself. Each of the last two proglottides of the strobila always contain but one set of reproductive glands, and also the genital ducts open on opposite sides of the strobila.

In *C. variabilis* the external appearance of the strobila is quite different. Instead of all the proglottides being even and regular, as in *C. pectinata*, there are many irregular and abnormal ones and many cases of intercalation. More than half of the strobilae possess abnormal proglottides and often twenty abnormalities occur in a single strobila. The simplest form of intercalation is seen in fig. 14. Here the proglottis, *a*, is represented only by a small lip on one side of the strobila and it possesses no internal organs. Fig. 15 shows a more typical case of intercalation. The proglottis, *a*, is the intercalated one, but from the external appearance of the strobila in this region *ac* would seem to be the normal one, and *b* the abnormal. The internal anatomy, however, the arrangement of the testes, and the perfectly formed transverse excretory canal show that *bc* is the normal proglottis. The proglottides *a* and *bc* are nevertheless closely connected. Although the transverse canal of *a* is lost in the parenchyma, the testes of *a* are continuous with those of *bc*, and the uterus of *a* dips backward into the parenchyma and between the uteri of *bc*. It should be noted that all of the uteri in this strobila are double. Fig. 16 shows a more peculiar case. The proglottides *ab* and *ef* are evidently normal. Now the question is whether *cd* is one proglottis with but one set of sexual glands, or is *c* an intercalated proglottis with one set of glands, and *d* another intercalated

proglottis with no sexual glands whatever. The latter view seems more probable since the transverse excretory canal of *c* in about the middle of the strobila turns forward and unites with that of *ab*, while *d* possesses neither sexual organs nor transverse excretory canal. Fig. 17 is a subcuticular section of the same proglottides, which shows that the margin of proglottis *d* is connected with *ab* and that of *c* with *ef*. Fig. 18 is a section through three proglottides. *Ab* represents one proglottis with only one set of reproductive glands, but it should be noticed that the proglottis is not normally developed on the side *a*. Fig. 19 shows a section through three proglottides of another strobila. The section was cut obliquely, so the three fully developed sets of organs of the left side are not shown. On the right side of section *ab* the reproductive glands are pushed mediad so that they lie just inside of the glands of the preceding and of the succeeding proglottides. The ovary, shell gland, and yolk gland are perfectly developed, and a portion of the receptaculum seminis is also present, but all genital ducts, as well as the genital pore, is absent. Testes are present but no vas deferens. Just how the eggs developing in this ovary are to become fertilized is a question. This proglottis seems to represent a stage intermediate between that represented in fig. 18 and a normal proglottis with two fully developed sets of female glands. Fig. 20 shows a proglottis *ab* with all the organs developed, but the margin on the right side is not developed, and the genital pore opens between the preceding and the succeeding proglottides. Fig. 21 shows a case, the most highly modified of all in some respects. The genital ducts on the right side of the proglottis *cd*, instead of opening on the normally developed margin *d*, turn forward and open with the ducts of the proglottis *ab*, so that four genital ducts open at the one genital pore. Unfortunately, the proglottis was so old that it was impossible to determine the exact relations of the four genital ducts.

The variety *angusta* also shows many abnormalities and intercalations similar to those of *C. variabilis* and occasionally normal proglottides with but a single pore.

The fact that proglottides are found with but a single set of reproductive organs is important in that it shows that proglottides with single and with double sets of generative organs may occur in the same strobila. But why in the case of *C. pectinata* the single sets should always occur only in the last two proglottides and why



the genital pores should always be on alternating sides of the strobila are questions yet to be explained. It hardly seems possible that these two proglottides can represent only one proglottis when the fact is considered that there are two sets of testes (fig. 3, *t*), two uteri (fig. 3, *u*), and that the transverse excretory canal (fig. 3, *t r*) in next to the last proglottis is perfectly developed.

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## EXPLANATION OF PLATES

## Plates XXVI, XXVII

## EXPLANATION OF ABBREVIATIONS USED

<i>b e c</i>	Blind pouch of excretory canals.	<i>o v</i>	Oviduct.
<i>c</i>	Cirrus.		Excretory reservoir.
<i>c i</i>	Cilia.	<i>r o</i>	Reservoir of ovary.
<i>c m</i>	Circular muscle fibers.	<i>s g</i>	Shell gland.
<i>c o</i>	Nerve commissures.	<i>s l c</i>	Secondary longitudinal canals
<i>c p</i>	Cirrus pouch.		of the parenchyma.
<i>d c</i>	Dorsal excretory canal.	<i>s m</i>	Sagittal muscle fibers.
<i>d n</i>	Dorsal nerve.	<i>s t</i>	Spongy tissue of cirrus sac.
<i>d s c</i>	Deeply staining cells.	<i>s p m</i>	Sphincter muscle.
<i>e c</i>	Excretory canal.	<i>t</i>	Testes.
<i>e p</i>	Excretory pore.	<i>t m</i>	Transverse muscle fibers.
<i>e r s</i>	Ext. receptaculum seminis.	<i>t r</i>	Transverse excretory canals.
<i>g</i>	Ganglion.	<i>u</i>	Uterus.
<i>g p</i>	Genital pit or pore.	<i>v</i>	Vagina.
<i>i</i>	Island of parenchyma.	<i>v c</i>	Ventral excretory canal.
<i>i r s</i>	Int. receptaculum seminis.	<i>v d</i>	Vas deferens.
<i>l m</i>	Longitudinal muscle fibers.	<i>v n</i>	Ventral nerve.
<i>m n</i>	Main nerve.	<i>v s</i>	Vesiculo seminalis.
<i>o</i>	Ovary.	<i>v t</i>	Vitellarium.
<i>o t</i>	Ootype.	<i>v t d</i>	Duct of vitellarium.

## EXPLANATION OF FIGURES

All figures are made from camera drawings.

Figs. 1-8. *Cittotaenia pectinata*.

Fig. 1. Dorsal view of male and female reproductive organs.  $\times 79$ .

Fig. 2. Frontal sections of scolex through ganglia and excretory canals.  $\times 93$ .

Fig. 3. Frontal sections through posterior proglottis.  $\times 12$ .

Fig. 4. Transverse section of proglottis.  $\times 32$ .

Fig. 5. Sagittal section through nerve trunks.  $\times 62$ .

Fig. 6. Head.  $\times 60$ .

Fig. 7. Secondary longitudinal canals of one proglottis.  $\times 68$ .

Fig. 8. Transverse section of cirrus pouch and vagina.  $\times 293$ .

Fig. 9. Single-pored form. Frontal section of one proglottis.  $\times 30$ .

Figs. 10-21. *C. variabilis*.

Fig. 10. Transverse section through proglottis.  $\times 30$ .

Fig. 11. Transverse section through head.  $\times 43$ .

Fig. 12. Frontal section through strobila showing main nerve trunk.  $\times 32$ .

Fig. 13. Frontal section through cirrus pouch and sphincter muscle.  $\times 93$ .

Figs. 14, 15, 16, 17, 18, 19, 20, and 21. Abnormal proglottides.  $\times 7$ .

Fig. 22. *C. variabilis angusta*. Frontal section of proglottis.  $\times 57$ .



PLATE XXVII

